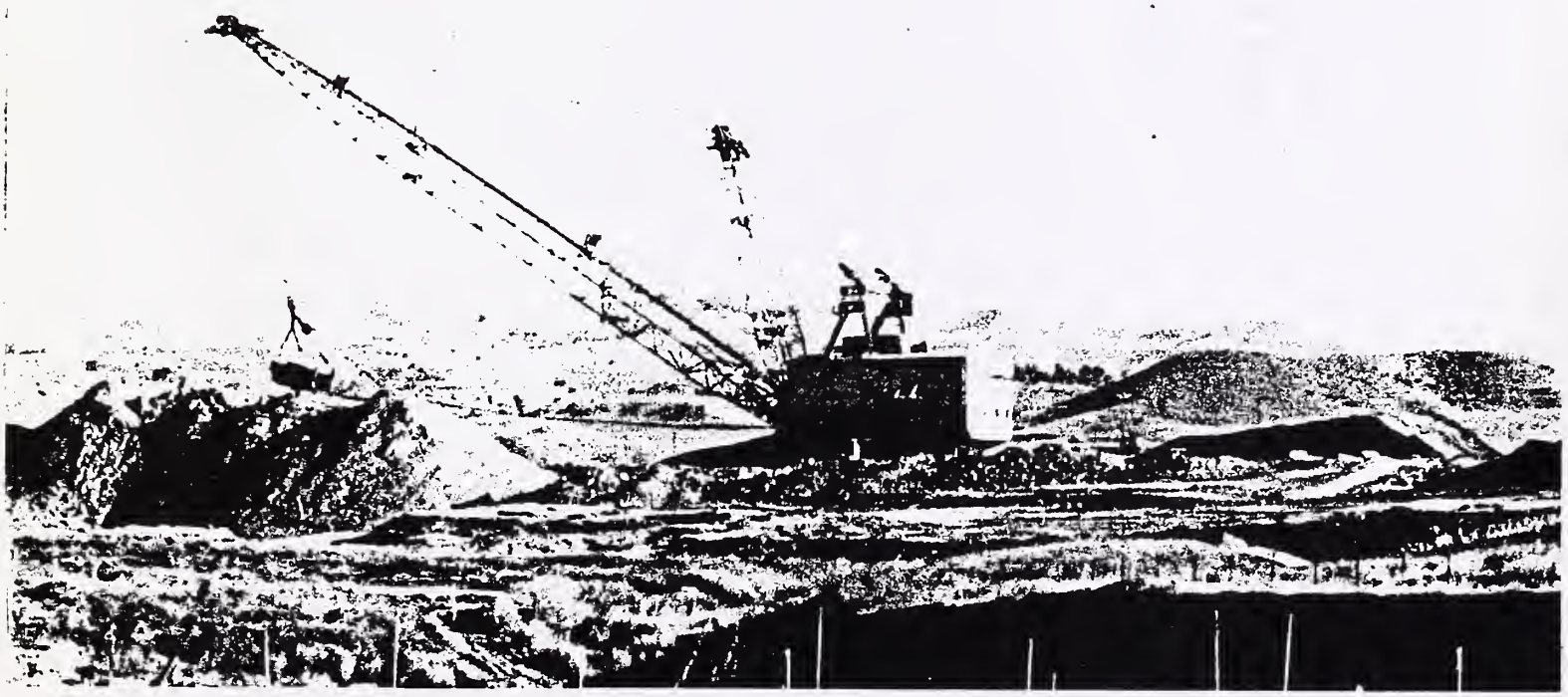
Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

A99.9 F764U

REVEGETATION RESEARCH ON THE DECKER COAL MINE IN SOUTHEASTERN MONTANA

Eugene E. Farmer, Ray W. Brown, Bland Z. Richardson, and Paul E. Packer



USDA Forest Service Research Paper INT-162, 1974
INTERMOUNTAIN FOREST AND RANGE
EXPERIMENT STATION
Ogden, Utah 84401

The research reported here is a contribution to the SEAM program. SEAM, an acronym for Surface Environment and Mining, is a Forest Service program to research, develop, and apply technology that will help maintain a quality environment and other surface values while helping meet the Nation's mineral requirements. SEAM is a partnership with all land managers, regional planners, mining industries, and political jurisdictions at all levels.

USDA Forest Service
Research Paper INT-162
November 1974

REVEGETATION RESEARCH ON THE DECKER COAL MINE IN SOUTHEASTERN MONTANA

Eugene E. Farmer, Ray W. Brown, Bland Z. Richardson, and Paul E. Packer

INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION
Forest Service
U.S. Department of Agriculture
Ogden, Utah 84401
Roger R. Bay, Director

EUGENE E. FARMER, Forest Hydrologist on the Watershed Protection and Rehabilitation research unit at Logan, Utah, joined the staff of the Intermountain Station in 1964. His principal interests have been in soil erosion and precipitation characteristics in mountainous terrain.

RAY W. BROWN is a plant physiologist with the Intermountain Forest and Range Experiment Station, stationed in Logan, Utah, since 1965. He received his B.S. and M.S. degrees in 1963 and 1965, respectively, from the University of Montana, and a Ph.D. in Plant Physiology in 1974 from Utah State University. His primary research interest and activity are in water relations and heat transfer characteristics of plants.

BLAND Z. RICHARDSON is a Research Forester stationed at the Forestry Sciences Laboratory of Intermountain Station, Logan, Utah. After completing engineering training at Yale University in 1944, Richardson was commissioned in the United States Air Force where he served until his retirement from active duty in 1952. Richardson received his B.S. degree in forestry from the University of Montana in 1963. In 1964 he joined Intermountain Station and was assigned to work in the field of watershed management. Since then he has been involved in a variety of research activities in that field.

PAUL E. PACKER is a 1939 graduate in forestry from the University of California. Subsequently he obtained an M.S. degree there. He has been employed as a research forester by the Forest Service for more than 30 years. He has made many research contributions in watershed management and is the author of more than 30 research publications. Among his most important accomplishments are development of watershed protection requirements for important western ranges and establishment of criteria for locating and designing logging roads to prevent sedimentation of streams. Since 1962 he has been project leader of the Watershed Protection and Rehabilitation research unit at Logan, Utah.

CONTENTS

Page

INTRODUCTION 1

SITE AND PLOTS 2

TREATMENTS 4

DATA COLLECTION 7

RESULTS 7

- Control Plot--Seedling Emergence 9
- Control Plot--Grass Yield 9
- Top-Dressed Plot--Seedling Emergence 9
- Top-Dressed Plot--Grass Yield 10
- Irrigated Plot--Seedling Emergence 10
- Irrigated Plot--Grass Yield 10

DISCUSSION 11

LITERATURE CITED 12

Use of commercial names in this report is for information only, and does not imply endorsement by the U.S. Department of Agriculture.

ABSTRACT

First-year results of revegetation research at the Decker coal mine in southeastern Montana are described. Three types of main plots were located on overburden material: (1) a control plot, (2) an irrigated plot, and (3) a plot dressed with topsoil materials. Each main plot consists of 48 subplots for a total of 144 subplots. Treatments included different grass mixtures, fertilizer, and mulch on irrigated and unirrigated plots. On the basis of dry-weight grass production, several treatments produced acceptable first-year grass stands. The top-dressing of mine overburden appears to be a highly desirable revegetation practice. Generally, wheatgrasses (Agropyron spp.) have dominated the dry-weight production.

INTRODUCTION

The revegetation of coal mined lands in the Northern Great Plains has recently become a focal point of interest by various Federal and State agencies, and private groups. At least in part, this interest stems from the fact that little quantitative information is available concerning the revegetation of mine spoils in the Western United States. This knowledge gap has resulted in opinions on revegetation possibilities ranging from the most pessimistic forecasts to the most optimistic.

One surface mine of great recent interest is the Decker coal mine in southeastern Montana. The Decker mine, situated on lands owned by the State of Montana, was opened as a result of the recent increased national need for fuel resources. Over the next several years, this mine is expected to develop into one of the largest coal mines in the United States.

The Decker mine is located near Decker, Montana, just north of Sheridan, Wyoming. Commercial operations started in 1971 in a subbituminous coal seam averaging about 50 feet thick. The coal is buried under approximately 60 feet of overburden. This overburden material is removed from the coal bed with heavy equipment and placed into an adjacent cut from which the coal has been removed.

The soils in the area of the mine are clayey and loamy Ustic Aridisols, often containing a large amount of sodium on the clay particles. Parent materials, shales or sandstones, are usually at depths greater than 30 inches. The general physiography is a succession of smooth divides and broad drainage bottoms of rolling land. However, buttes of red scoria and shale outcrops are common landscape features; these sites are usually occupied by badlands vegetation (Brown 1971).

The natural vegetation of the general area reflects the annual precipitation of about 15 inches. It consists primarily of mixed grass prairie and scattered shrubs. The dominant vegetation on the gently rolling slopes is needle-and-thread (*Stipa comata*), green needle-grass (*S. viridula*), western wheatgrass (*Agropyron smithii*), blue grama, (*Bouteloua gracilis*), and big sagebrush (*Artemisia tridentata*). In the swales, salt grass (*Distichlis stricta*), western wheatgrass, and big sagebrush are dominants.

The research reported here includes the first-year results of a revegetation study at the Decker mine. The research was initiated during the summer of 1972, and plantings were made on mine overburden materials in October 1972. The major long-term objective of this study is to provide several alternative prescriptions for achieving a permanent plant cover on disturbed sites of the Decker coal mine.

SITE AND PLOTS

The site selected for study (fig. 1) was on level overburden material, chosen to avoid the effects of slope, aspect, and steepness, and to avoid complications associated with seed and plant nutrient movement through erosional processes. The overburden materials on the study site came from the original coal test pit, located about 200 feet east of the study site. These materials were graded level. Topsoil, as needed, was hauled to the site for the research study.

Three types of main plots were located on the overburden material: (1) a control plot, (2) an irrigated plot, and (3) a plot on which the overburden material was top-dressed with about 8 inches of soil materials that originated in the surface 3 feet. Each main plot consists of 48 subplots, each 8 feet square.

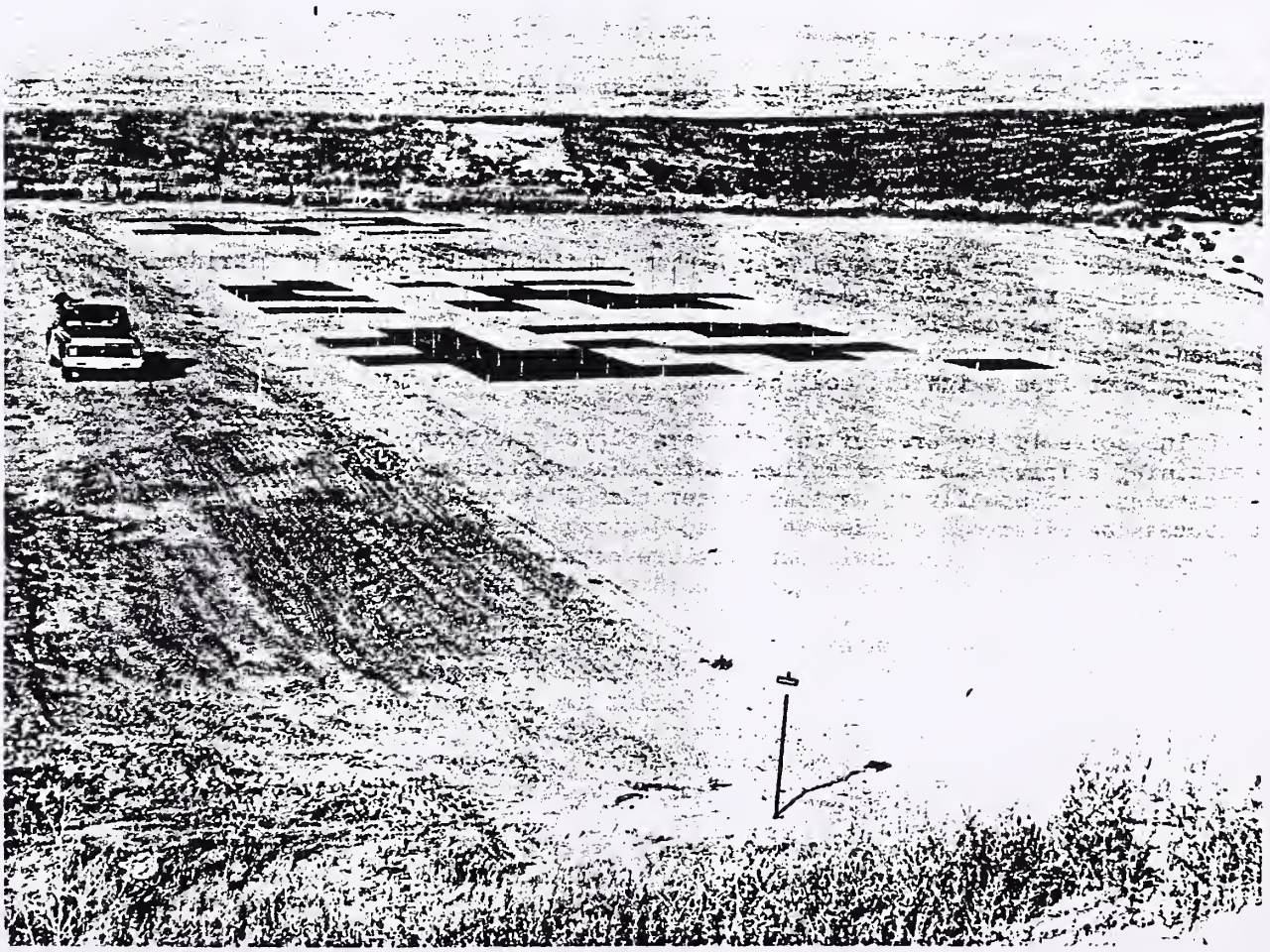


Figure 1.--View of the study site just after planting, October 1972; looking generally northeast. The darker areas are mulched subplots.

Results of analyses of 10 samples of Decker mine overburden materials are shown in table 1 (Hodder and Sindelar 1972). The study site generally tends toward the heavier soil textures, (samples 4 through 10). The top-dressed main plot has a slightly better soil structure than the main plots located on overburden materials, but soil chemistry does not appear to be appreciably different. Soil samples numbers 9 and 10 were taken from top-dressed main plot.

Table 1.--*Soil analyses of some overburden materials at the Decker coal mine*

Sample	pH	Total salts (Mmho/cm)	Available nutrients (p/m)		Texture
			P	K	
1	8.5	2.9	2.4	111	Sandy loam
2	7.2	.6	15.0	278	Sandy loam
3	7.0	.6	2.2	180	Sandy loam
4	8.8	1.6	0	153	Sandy loam
5	8.4	4.2	0	153	Clay
6	8.8	0.7	0.4	101	Loamy clay
7	8.4	2.2	0	234	Clay
8	8.8	.9	0	143	Clay
9	7.9	2.2	12.0	226	Sandy clay
10	8.2	3.0	15.0	199	Sandy clay

TREATMENTS

Twelve treatments were replicated four times on each main plot. The treatments were: three grass seed mixtures alone, and the mixture with fertilizer, or mulch, or both, table 2.

Table 2.--*Subplot treatments replicated four times on each of three main plots*

Grass mixture	Fertilizer	Mulch
Native	Yes	Yes
Pasture	Yes	Yes
Native + Pasture	Yes	Yes
Native	Yes	No
Pasture	Yes	No
Native + Pasture	Yes	No
Native	No	Yes
Pasture	No	Yes
Native + Pasture	No	Yes
Native	No	No
Pasture	No	No
Native + Pasture	No	No

Seed mixtures.--The grass seed mixtures consisted of: (1) native species, (2) introduced species, and (3) a mixture of native and introduced species. All seed mixtures were combined with rice hulls as a carrying agent. Species present in each mixture were:

	Lb/acre
NATIVE SPECIES	
Green needlegrass *(Stipa viridula)*	4.5
Western wheatgrass *(Agropyron smithii)*	6.0
Blue grama *(Bouteloua gracilis)*	3.0
Little bluestem *(Andropogon scoparius)*	1.5
Sideoats grama *(Bouteloua curtipendula)*	3.0
Indian ricegrass *(Orysopsis hymenoides)*	1.5
Slender wheatgrass *(Agropyron trachycaulum)*	4.5
Big bluestem *(Andropogon gerardi)*	1.5
Total	25.5
INTRODUCED SPECIES	
Fairway crested wheatgrass *(Agropyron cristatum)*	3.0
Nordan crested wheatgrass *(Agropyron cristatum)*	3.0
Russian wildrye *(Elymus junceus)*	4.5
Pubescent wheatgrass *(Agropyron trichophorum)*	3.0
Intermediate wheatgrass *(Agropyron intermedium)*	3.0
Smooth brome (Manchar) *(Bromus inermis)*	3.0
Winter rye *(Secale cereale)*	3.0
Tall wheatgrass *(Agropyron elongatum)*	3.0
Total	25.5
NATIVE PLUS INTRODUCED SPECIES	
Fairway + Nordan crested wheatgrass *(Agropyron cristatum)*	4.5
Green needlegrass *(Stipa viridula)*	3.0
Smooth brome *(Bromus inermis)*	3.0
Western wheatgrass *(Agropyron smithii)*	4.5
Russian wildrye *(Elymus junceus)*	3.0
Blue grama *(Bouteloua gracilis)*	1.5
Intermediate wheatgrass *(Agropyron intermedium)*	3.0
Slender wheatgrass *(Agropyron trachycaulum)*	3.0
Total	25.5

All native grass seed used in this study originated in the general area of Decker, Montana. The native seed was collected by hand during the summer and cleaned before use. The native species selected are some of the principal dominants in the area, but also included some subdominants and seral species. The introduced species, all of which grow successfully in the vicinity of the Decker mine, were obtained commercially. All species selected appeared to have potential for revegetation use as evidenced by their observed occurrence and growth on other disturbed sites (road cuts and fills) in the area.

Fertilizer and mulch.--Fertilizer was a commercial granular 15-40-5 type mixed with a silica sand carrying agent. Commercial sphagnum peat moss, covered with a single layer of jute netting, was the mulch used.

Preparation and application.--Seedbed preparation consisted of ripping all soils to a depth of 10 inches, and then harrowing several times with a spring-toothed harrow until the soils were friable and no large clods were present on the surface. Care was taken to insure that the treatments were applied uniformly and confined to the appropriate subplot area. A small seed spreader was used to apply fertilizer on appropriate subplots at the rate of 300 pounds per acre and the fertilizer was raked in manually. Seed mixtures then were applied to all plots at a rate of 25.5 pounds per acre and raked lightly. Mulch was applied at a rate of 2.5 tons per acre where appropriate, and the entire study site was packed down with a Brillion Culti-Packer.

Irrigation.--From May 18 through October 4, 1973, irrigation water was applied to the irrigated main plot at the rate of 1-1/2 inches per week in five daily applications of 0.3 inch. The sprinkler irrigation system was completely automated and provided a uniform application (uniformity coefficient 0.97).

The study site is approximately 200 feet from a coal test pit 80 feet deep, from which ground water was pumped and used as the irrigation water supply. This ground water is of low quality for irrigation purposes, principally because of the high sodium content (table 3). Other sources of irrigation water were considered impractical because of costs, transportation difficulties, or water right problems. The Decker Coal Company had been successfully using the pit water in short term irrigation projects.

During the second week of August, 2 months after irrigation started, soil analyses on the irrigated plot showed that conditions for plant growth were deteriorating. The pH near the soil surface was nearly 10, and exchangeable soil sodium had increased by 100 percent. To counteract this trend, calcium chloride was applied to the irrigated plot at the rate of 2,700 pounds per acre. The calcium chloride was applied over a 2-week period through the irrigation system as a saturated solution mixed 1:60 with the irrigation water.

Table 3.--*Results of analysis of ground water used for irrigation on the Decker coal mine*

pH	Total salts (Mmho/cm)	Other constituents (p/m)			
		Na	Ca	Mg	HCO_3
8.8	1,533	350	2.6	5.0	1,197

DATA COLLECTION

Two types of data were collected for each of the 144 subplots: (1) grass stand density, and (2) estimates of the dry weight grass production. During data collection, all measurements and counts were made on the interior 6- by 6-foot area of each subplot. This action separated subplot treatments with a buffer zone 2 feet wide.

Early in the growing season, seedling emergence was assessed by making grass seedling density estimates on the top-dressed plot and on the control plot only. All of the seedlings were counted on a randomly selected 10-square-foot area of each subplot.

Estimates of the dry-weight production of grass on each subplot were made during the first week of October 1973. Nondestructive sampling was imperative since future measurements are required. Therefore, the Neal capacitance meter, Model 18-1000, was used to estimate production (Neal and Neal 1973). To calibrate the capacitance meter, one of every six herbage plots (1 by 2 feet) read with the meter was clipped and the dry weight measured. The influence of weeds on the capacitance readings was a complicating factor; however, the weed effect was accounted for by clipping them separately from the grasses. The weight of weeds was excluded from all analyses reported here.

RESULTS

During the 1973 growing season, weather conditions were generally favorable for plant growth. From April through September, precipitation amounts were approximately 15 percent above the long-term mean. Average daily air temperature was slightly below normal. Therefore, for the Decker mine site, the weather during this first growing season can be characterized as cool and moist.

Figure 2 summarizes the grass production results. Generally the greatest yields came from the mixture of introduced grasses, which averaged 789 pounds per acre, and the smallest yields from the mixture of native grasses, which averaged 629 pounds per acre. However, the native grass mixture performed better than expected in the first growing season with a maximum production of 1,543 pounds per acre. Several of the more favorable treatments yielded native grass stands that would provide good erosion protection to the soil (fig. 3).

Data on both seedling emergence and dry weight production were analyzed for variance. A confidence level of 95 percent was used to determine significant differences.

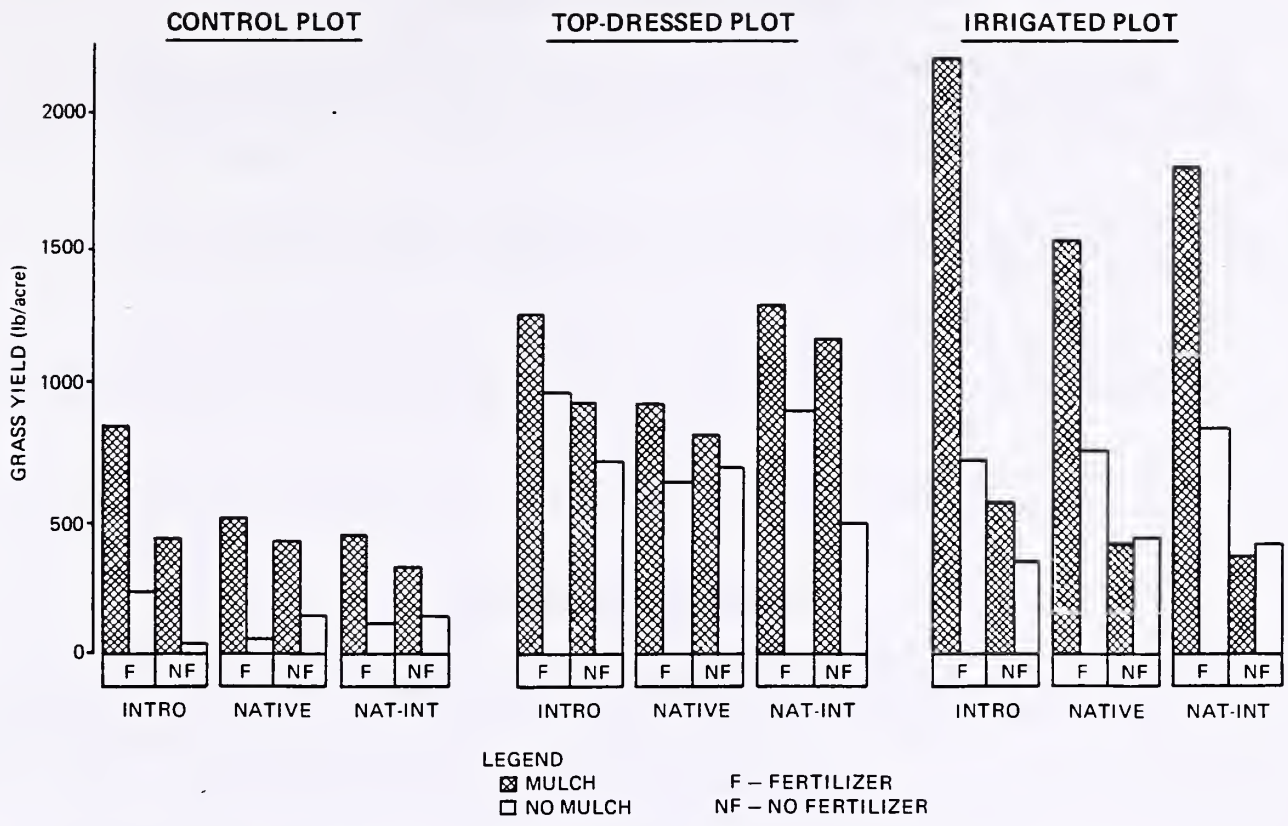


Figure 2.--Average dry-weight grass production, for each main plot by subplot treatments. INTRO, NATIVE, and NAT-INT are seed mixtures.

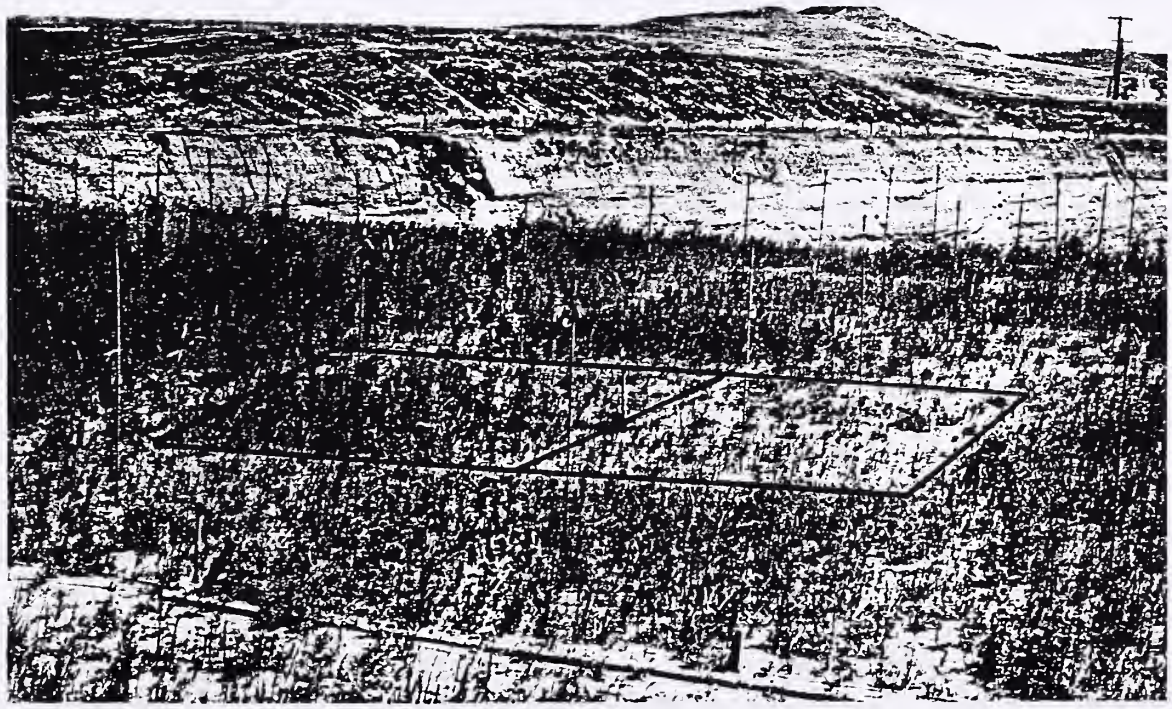


Figure 3.--View of a portion of the study site, October 1973. Irrigated subplots of native grasses are indicated. The subplot to the left was fertilized; the one to the right was not.

Control Plot--Seedling Emergence

Seedling emergence on the control plot was entirely satisfactory, regardless of subplot treatments. Seedling counts ranged from 11 to 22 per square foot; the average was 17 per square foot. The analysis of variance on the effects of seed mixture, mulch, and fertilizer showed:

1. There was a significant difference in seedling emergence due to grass mixture. The mixture of introduced grasses emerged best (22 per square foot) the native-introduced mixture next (19 per square foot) and the native mixture poorest (11 per square foot).

2. There was a significant difference in seedling emergence due to mulch. The average count on mulched plots was 21 per square foot as opposed to 14 per square foot on unmulched plots. The beneficial effect of mulch decreased in the following order: introduced grasses > native plus introduced grasses > native grasses.

3. There was no significant difference in seedling emergence due to fertilizer treatment; fertilized plots had 17 per square foot, and the unfertilized plots had 18 per square foot.

Control Plot--Grass Yield

As expected, the control plot produced less grass than either of the other main plots. The fertilized, mulched subplots produced the best stands and provided marginally acceptable grass cover. The relatively good stands of grass on the unfertilized, mulched subplots were not expected, and are unexplained. This effect will be monitored for several years to determine if it persists.

The analysis of variance on the dry-weight production data showed:

1. The mixture of introduced grass species gave significantly higher yields than either the native grass mixture or the native-introduced grass mixture. Yields from the latter two mixtures were not significantly different.

2. Mulch significantly increased the production of all grass mixtures.

3. The effect of fertilizer is modified by the effect of mulch. On unmulched subplots there was no fertilizer effect, but on mulched subplots fertilizer significantly increased production. The effect of fertilizer was not uniform for all grass mixtures, significantly increasing the production of the introduced grass mixture, but not of the other two mixtures.

Top-Dressed Plot--Seedling Emergence

Seedling counts on the top-dressed plot ranged from 10 to 19 per square foot; the average was 16 per square foot. These counts are sufficiently high to produce good grass stands. The analysis of variance on the effects of seed mixture, mulch, and fertilizer on seedling emergence showed:

1. There was no significant difference in seedling emergence between the native-introduced grass mixture (19 per square foot) and the introduced grass mixture (18 per square foot). The native grasses had significantly poorer emergence (10 per square foot) than did the other two.

2. There was a significant difference in seedling emergence due to mulch. The average count on mulched plots was 20 per square foot as opposed to 11 per square foot on unmulched plots. The beneficial effect of mulch decreased in the following order: introduced grasses > native plus introduced grasses > native grasses.

3. There was a significant interaction between fertilizer and mulch (the effect of fertilizer on seedling emergence depended on the mulch treatment). On unmulched plots, fertilizer had no effect. On mulched plots fertilizer decreased emergence from 21 to 19 per square foot.

Top-Dressed Plot--Grass Yield

Grass production on the top-dressed plot was generally satisfactory regardless of subplot treatments, the lowest production figure being 502 pounds per acre. Production differences among treatments were usually smaller than on the other main plots. The analysis of variance of the dry-weight production showed:

1. The two grass mixtures that contained introduced grass species produced significantly greater yields than did the native grass mixture.

2. Mulch significantly increased the production of all grass mixtures.

3. Fertilizer significantly increased the production of all grass mixtures.

Irrigated Plot--Seedling Emergence

Seedling emergence counts were not made on the irrigated plot. However, limited count data and visual estimates convinced the authors that seedling counts on the irrigated plot would produce results similar to the counts made on the control plot.

Irrigated Plot--Grass Yield

Among main plots, the irrigated plot produced the greatest average yields. Subplots that were fertilized and mulched produced 2,238, 1,813, and 1,543 pounds per acre for introduced, native-introduced, and native grass mixtures, respectively. In the absence of either mulch or fertilizer, yields showed a marked decrease. There were no indications that the use of low quality irrigation water (table 3) adversely affected yields during the first growing season. However, the irrigation water was a source of a great increase in exchangeable soil sodium, necessitating correction with calcium chloride.

The analysis of variance on production data for the irrigated plot showed:

1. There was no significant difference in yield due to the use of different grass mixtures.

2. Mulch significantly increased the production of all grass mixtures.

3. Fertilizer significantly increased the production of all grass mixtures.

DISCUSSION

This study was designed to test a broad spectrum of potential treatments to determine the minimum combination of different treatments necessary to provide an acceptable plant cover. These first-year results do not conclusively indicate the minimum combination; more time will be required for that. However, there are strong trends in the data that suggest which treatments may be most acceptable.

There are no indications that the raw overburden material had any adverse effects on either seed germination or seedling emergence. Seedling counts early in the growing season showed plentiful vegetation on all subplots. This result is partially attributed to thorough seedbed preparation and packing the seedbed after sowing.

On the basis of dry-weight production, several treatments yielded grass stands capable of adequately protecting the spoil material against either water or wind erosion. The greatest yields were on irrigated subplots that were both fertilized and mulched. However, this treatment cannot as yet be recommended for two reasons: (1) continued irrigation with the present water supply will probably create strongly adverse soil conditions that will require correction, and (2) there is no information as yet on the consequences of stopping irrigation. These limitations also apply to irrigated plots that were fertilized but not mulched. The unfertilized irrigated subplots yielded rather poor stands and do not, at this time, appear to offer a desirable alternative.

All of the subplots located on the top-dressed soil yielded acceptable stands. Fertilizer had some positive effect, though not as large as expected. The principal objection to top-dressing, aside from cost considerations, will probably be the presence of weed seeds in the topsoil. On the average, over the entire top-dressed plot, only 47 percent of the total yield was in desirable grass species; the rest was in weeds, principally summer cypress (*Kochia scoparia*), Russian thistle (*Salsola kali*), and Japanese brome (*Bromus japonicus*). If top-dressing is practiced, some type of weed control program seems desirable. Generally, the control plots did not produce adequate grass stands in the first year. An exception may be the control plots that are both fertilized and mulched, but these plots are only marginally acceptable.

Grass yield means may be grouped according to grass mixture and ranked by treatment (fig. 4). This grouping combines the results from control, irrigated, and top-dressed plots and is useful for making comparisons among the treatments for each grass mixture. For instance, none of the grass mixtures on the control plot produced 500 pounds per acre of dry matter without both fertilizer and mulch. Except for the irrigated plots that were mulched and fertilized, the top-dressed plots generally yielded the greatest grass weights. According to these first-year results the top-dressing of mine overburden, regardless of mulch or fertilizer, appears to be a highly desirable revegetation practice.

In each seed mixture the wheatgrasses dominated the dry-weight production. Generally, wheatgrass seedlings were identified only as *Agropyron* spp. However, the slender wheatgrass plants were exceptionally vigorous and many produced seed in the first growing season. Smooth brome was a notable component of both the introduced and native-introduced grass mixtures, but usually did not set seed. In the native grass mixture, sideoats grama is an important stand component. More complete species information will be collected as the study progresses.

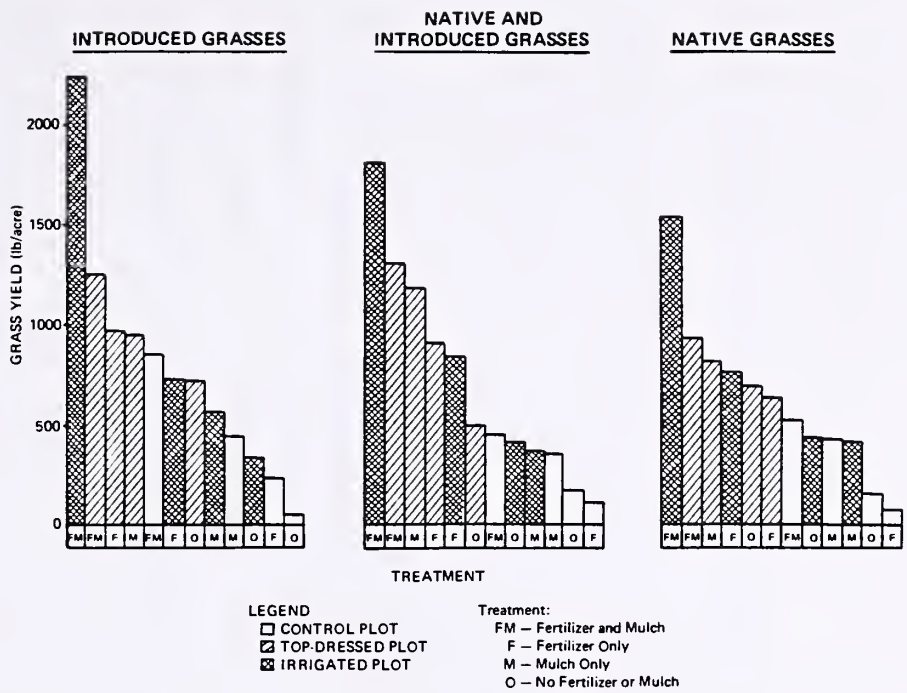


Figure 4.--Mean dry-weight grass production by treatment, ranked within grass mixtures.

These data do not give a strong basis for choosing between the three grass mixtures under study. Clearly, the mixture of introduced grasses has outproduced the other two mixtures. However, the long-term considerations favor the native species as being most likely to hold the site in spite of drought, insects, and disease. Also, some native grasses have responded very favorably to some treatments. Probably the major disadvantage of using a mixture of only native grass species is the almost complete commercial unavailability of native grass seed. This may be a serious limitation to large-scale revegetation efforts. It would probably be a mistake to completely ignore the many desirable species of introduced grasses in the revegetation of surface-mined areas.

It is important to recognize that this study concerns the revegetation of one type of mine overburden material. At the Decker mine there are other overburden materials that vary in both chemical and physical properties from the one under study. Other mine sites have other types of overburden material.

LITERATURE CITED

Brown, R. W.
1971. Distribution of plant communities in southeastern Montana badlands. Am. Midl. Nat. 85:458-477.

Hodder, R. L., and B. W. Sindelar.
1972. Coal mine land reclamation research, location - Decker, Montana. Mont. State Univ. Agric. Exp. Stn., Res. Rep. 21, Bozeman, Mont.

Neal, D. L., and J. L. Neal.
1973. Uses and capabilities of electronic capacitance instruments for estimating standing herbage. J. Br. Grassland Soc. 28:81-89.

☆U.S. GOVERNMENT PRINTING OFFICE. 1975 — 677-328 / 13 REGION NO. 8

FARMER, EUGENE E., RAY W. BROWN, BLAND Z. RICHARDSON, and PAUL E. PACKER

1974. Revegetation research on the Decker coal mine in southeastern Montana. USDA For. Serv. Res. Pap. INT-162, 12 p., illus. (Intermountain Forest & Range Experiment Station, Ogden, Utah 84401.)

First-year results of revegetation research at the Decker coal mine in southeastern Montana are described. Three types of main plots were located on overburden material. Treatments included different grass mixtures, fertilizer, and mulch on irrigated and unirrigated plots. On the basis of dry-weight grass production, several treatments produced acceptable first-year grass stands. The top-dressing of mine overburden appears to be a highly desirable revegetation practice.

OXFORD: 268:41; 237.
KEYWORDS: revegetation research, surface mine revegetation, coal mine reclamation, Northern Great Plains.

FARMER, EUGENE E., RAY W. BROWN, BLAND Z. RICHARDSON, and PAUL E. PACKER

1974. Revegetation research on the Decker coal mine in southeastern Montana. USDA For. Serv. Res. Pap. INT-162, 12 p., illus. (Intermountain Forest & Range Experiment Station, Ogden, Utah 84401.)

First-year results of revegetation research at the Decker coal mine in southeastern Montana are described. Three types of main plots were located on overburden material. Treatments included different grass mixtures, fertilizer, and mulch on irrigated and unirrigated plots. On the basis of dry-weight grass production, several treatments produced acceptable first-year grass stands. The top-dressing of mine overburden appears to be a highly desirable revegetation practice.

OXFORD: 268:41; 237.
KEYWORDS: revegetation research, surface mine revegetation, coal mine reclamation, Northern Great Plains.

FARMER, EUGENE E., RAY W. BROWN, BLAND Z. RICHARDSON, and PAUL E. PACKER

1974. Revegetation research on the Decker coal mine in southeastern Montana. USDA For. Serv. Res. Pap. INT-162, 12 p., illus. (Intermountain Forest & Range Experiment Station, Ogden, Utah 84401.)

First-year results of revegetation research at the Decker coal mine in southeastern Montana are described. Three types of main plots were located on overburden material. Treatments included different grass mixtures, fertilizer, and mulch on irrigated and unirrigated plots. On the basis of dry-weight grass production, several treatments produced acceptable first-year grass stands. The top-dressing of mine overburden appears to be a highly desirable revegetation practice.

OXFORD: 268:41; 237.
KEYWORDS: revegetation research, surface mine revegetation, coal mine reclamation, Northern Great Plains.

FARMER, EUGENE E., RAY W. BROWN, BLAND Z. RICHARDSON, and PAUL E. PACKER

1974. Revegetation research on the Decker coal mine in southeastern Montana. USDA For. Serv. Res. Pap. INT-162, 12 p., illus. (Intermountain Forest & Range Experiment Station, Ogden, Utah 84401.)

First-year results of revegetation research at the Decker coal mine in southeastern Montana are described. Three types of main plots were located on overburden material. Treatments included different grass mixtures, fertilizer, and mulch on irrigated and unirrigated plots. On the basis of dry-weight grass production, several treatments produced acceptable first-year grass stands. The top-dressing of mine overburden appears to be highly a highly desirable revegetation practice.

OXFORD: 268:41; 237.
KEYWORDS: revegetation research, surface mine revegetation, coal mine reclamation, Northern Great Plains.

Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Field Research Work Units are maintained in:

Boise, Idaho
Bozeman, Montana (in cooperation with Montana State University)
Logan, Utah (in cooperation with Utah State University)
Missoula, Montana (in cooperation with University of Montana)
Moscow, Idaho (in cooperation with the University of Idaho)
Provo, Utah (in cooperation with Brigham Young University)
Reno, Nevada (in cooperation with the University of Nevada)